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SHORT TERM IMPACT OF CARBARYL
ON OOENCYRTUS KUWANAI (HOWARD)

by

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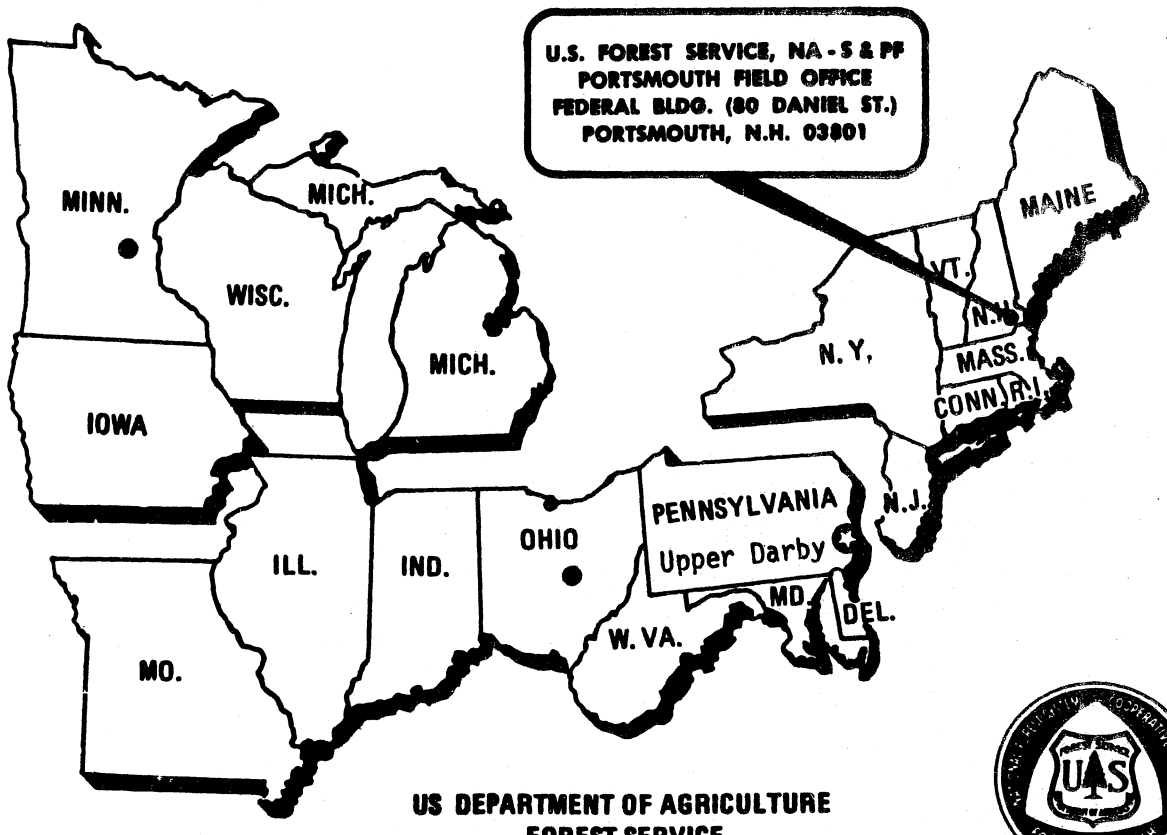

US DEPARTMENT OF AGRICULTURE
FOREST SERVICE

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ABSTRACT

Gypsy moth egg masses collected in the winter from unsprayed and sprayed areas in New Jersey and New York following application of one pound active ingredient carbaryl in water were compared for percent parasitism by Ooencyrtus kuwanai. The spraying had no impact on the population intensity of the parasite in terms of percent parasitism. Mean percent parasitism was greatest in small egg masses and least in large egg masses. Egg masses collected from niches less than one foot above the forest floor are likely to have a lower rate of parasitism than those from more than one foot above the forest floor.

PREFACE

The introduced gypsy moth (Porthetria dispar (L)) (Lepidoptera:Liparidae)[7] is a major pest in New England, New York, New Jersey and Pennsylvania where it defoliates species of oak and other tree species in the forest environment.[5] In 1971, proposals were made to reduce the impact of gypsy moth populations by application of carbaryl (Sevin) at the rate of one pound per acre on some infested areas in New York and New Jersey. [1][2][3] These proposals were carried out in June, 1971 when 241,000 acres were treated in New York and 55,000 acres in New Jersey. A plan[4] was made to evaluate the effectiveness of the carbaryl treatments. A portion of this plan required the collection of gypsy moth egg masses near 0.10 acre plots.

Ooencyrtus kuwanai (Howard) (Hymenoptera:Encyrtidae)[7] is a parasite of gypsy moth eggs where it attacks and destroys the newly-formed caterpillars. This parasite, imported from Japan, was first released in Massachusetts in 1909.[8] Since then, many releases have been made in New England and New Jersey. The parasite overwinters as a gravid female in forest litter and spends its summers in unhatched gypsy moth eggs. The first generation begins in March when the hibernating females emerge to oviposit in eggs of the gypsy moth. This first generation, which requires six weeks for development, terminates with the hatch of gypsy moth. The second (spring) generation requires three weeks for completion and terminates before spraying operations begin for control of gypsy moth.

It has been suggested that "In general, hymenopterous and feeding phytophagous species may be appreciably affected"[1] by application of carbaryl for control of gypsy moth. Concerned citizens feared the impact of carbaryl on parasites of the gypsy moth. For example, a Newark, N. J. resident quoted a New York Times article of August 31, 1971: "...yet insects that prey on them (gypsy moth) ...small in number to begin with... are so heavily hit that they are not on hand to serve as a control."[9] Another citizen in Lakewood, N. J. charges that carbaryl does not permit nor encourage control of gypsy moth by its natural enemies.[9]

This report considers the progress of a study to determine the impact of carbaryl, when applied in water from aircraft, on Ooencyrtus kuwanai. Hopefully, this report will aid in the search for information on the impact of spraying.

ACKNOWLEDGEMENTS

The cooperation and efforts of the personnel in the New Jersey Division of Plant Industry, the New Jersey Bureau of Forestry and the New York Department of Environmental Conservation are gratefully acknowledged. Without their support, especially of Messrs. Morgan, Edelman, Chammings, Albert, Morawaski, Vaughan, Roberty, Denk, Wagner, and Baranger, the study plots would not have been established. I also appreciate the efforts of many Forest Service people who counted, collected and sorted the egg masses used for this report. Among those instrumental in getting the job done were Messrs. Saufley, Snowden, Andrews, Currier, Smith, Hare, Jahns, Bateman, Anderson, Day, Marquis, Magoon, Wilson, Hubbard, and Osmick.

INTRODUCTION

One of the objectives of the work plan, "Evaluating Effectiveness of 1971 Gypsy Moth Suppression Projects in New York, Pennsylvania, and New Jersey", is to determine the short-term (1 year) effectiveness of a single application of carbaryl in reducing gypsy moth populations. Included in this objective is a comparison of variations in Ooencyrtus populations. These variations were calculated from New York and New Jersey egg mass collections gathered in November and December, 1971, six months after spraying with carbaryl for the control of gypsy moth. O. kuwanai population intensity is expressed as a percentage of parasitism in individual gypsy moth egg masses.

OBJECTIVE

To determine the impact on the population intensity of Ooencyrtus kuwanai when woodlands of New York and New Jersey were sprayed with one pound of carbaryl in water for control of gypsy moth populations in 1971.

SAMPLE SELECTION

Gypsy moth egg masses were collected at random from within three strata:

(1) New York and New Jersey

(2) Areas treated with carbaryl and untreated areas.

(3) More than one foot above the ground surface and between the forest floor and less than one foot above the ground level.

The intent was to collect 10 egg masses from the vicinity of each of 600 plots previously established. However, egg masses were not always available within one acre surrounding every plot - especially in the treated areas. A total of 2,122 egg masses were collected from the different strata as listed in Table 1.

TABLE 1.

NUMBER AND DISTRIBUTION OF GYPSY MOTH EGG MASSES COLLECTED FROM THREE STRATA

	ABOVE 1 FOOT		BELOW 1 FOOT*		
STATE	UNTREATED	TREATED	UNTREATED	TREATED	TOTAL
N.Y.	579	156	467	121	1323
N.J.	284	144	245	126	799
	863	300	712	247	2122

*Between forest floor and 1' above it.

The following designations are used throughout this report:

NY is New York and NJ is New Jersey.
T is treated with carbaryl and U is untreated

A is found higher than 1 foot above the ground
B is found between ground level and up to 1 foot above the ground.

From the initial collection of 2,122 egg masses, a subsample of 920 egg masses was chosen at random to represent NYT, NYU, NJT and NJU, in equal amounts of 230 egg masses each. The subsample was representative of the gypsy moth population in terms of political boundaries, egg mass population counts per 0.1 acre, and timber types. Such representation is shown in Appendix I.

Samples were collected when the gypsy moth was readily visible in its 9 month-quiescent egg stage. Since O. kuwanai overwinter as gravid females in the litter, parasitized eggs were easy to identify in the laboratory when the major amount of parasitism (3-4 generations) had occurred. The sampling did not take into account the two spring generations of O. kuwanai.

Dowden[10/] indicated a strong correlation between gypsy moth egg mass size and percent parasitism by O. kuwanai; therefore, our egg masses were also segregated by size as follows:

Spatters	1- 50 eggs
Small	51-250 eggs
Medium	251-500 eggs
Large	501-800 eggs
Extra Large	801+ eggs

As calculations proceeded, I found it necessary to draw additional egg masses for the subsample from N.J.U.A. (11 egg masses) and N.J.U.B. (3 egg masses). These were not random selections, but were all that remained of the "large" egg masses.

The number of egg masses in each category, by State and spray treatment are shown in Table 2.

Each egg mass was cleaned (de-haired) and the eggs counted and sorted according to the method developed by Saufley.[12/]

TABLE 2.

FREQUENCY TABLE OF NUMBER OF GYPSY MOTH EGG MASSES BY SIZE CLASSES. COLLECTIONS MADE IN NOVEMBER AND DECEMBER 1971 FROM CARBARYL-TREATED AREAS AND UNTREATED AREAS IN NEW YORK AND NEW JERSEY

	NUMBER OF EGG MASSES PER CLASS				
No. of Eggs in class	NYT	NYU	NJT	NJU	TOTAL
0 - 50	1	1	2	2	6
51 - 250	119	75	52	154	400
251 - 500	86	104	81	69	340
501 - 800	18	44	71	4	137
801 +	6	6	24	1	37
Totals	230	230	230	230	920

CALCULATIONS

The subsample of 920 egg masses was arrayed in a series of frequency tables (Table 3) according to state, treatment, and percent parasitism by O. kuwanai, and shown graphically (Fig. 1).

TABLE 3.
FREQUENCY OF PERCENT PARASITISM BY O. KUWANAI IN GYPSY MOTH EGG MASSES COLLECTED FROM NEW YORK AND NEW JERSEY THE WINTER FOLLOWING APPLICATION OF CARBARYL, 1971

% Parasitism Class	Number of Egg Masses in Each Class for: NYT	NYU	NJT	NJU
0 - 0.1	2	1	3	0
0.01 - 10	10	10	9	6
10.01 - 20	21	38	41	15
20.01 - 30	50	61	74	44
30.01 - 40	67	59	61	67
40.01 - 50	50	41	24	55
50.01 - 60	21	15	9	26
60.01 - 70	8	2	3	12
70.01 - 80	1	1	1	2
80.01 - 90	0	0	2	2
90.01 -100	0	2	3	1
Totals	230	230	230	230
True Mean	34.95	31.70	30.10	38.37

The original percent parasitism, calculated from total number of eggs per mass divided by the number of parasitised eggs then multiplied by 100, was transformed to arcsin $\sqrt{\%}$ as recommended by Steel and Torrie.[14] The transformation reduced variances and increased means so that ordinary statistical procedures could be used in analysis.[13] Graphic methods indicated that variance and means were unrelated. Appendix II shows by Bartlett's test that variance was homogeneous.[11]

Examination of the data as arranged in Table 2 indicated some inconsistencies in the size of egg masses between states and treatments. It also demonstrated that there were insufficient egg masses in the spatter (1-50) and extra large (800 +) categories for meaningful analysis. The mean percent parasitism by state, treatment and size class (transformed data) were:

	Small	Medium	Large
NYT	39.09%	32.72%	30.99%
NYU	39.41	32.82	27.12
NJT	38.82	32.82	28.16
NJU	38.82	35.21	27.76

Prior to comparing these means to determine any differences between states, treatment, or egg mass size, I used a series of *t* tests to verify the need to separate egg masses according to position (above or below one foot level over the forest floor) with the following results:

Small egg masses - calculated *t* = 0.405 not significant
tabular *t* (.05) = 1.96
N = 200

Medium egg masses - calculated *t* = 1.726 not significant
tabular *t* (.05) = 1.96
N = 200

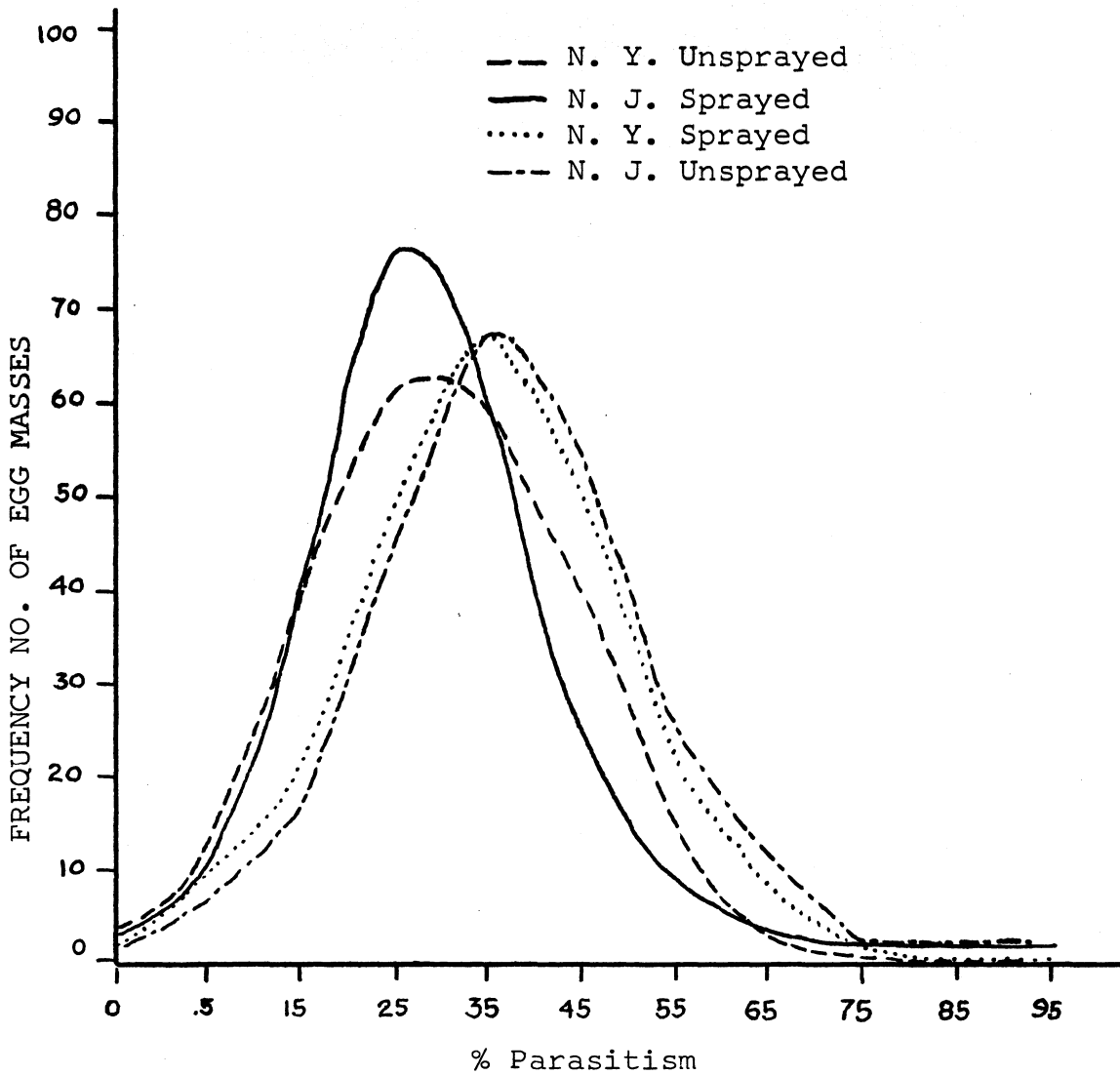
Large egg masses - calculated *t* = 8.836 significant
tabular *t* (.05) = 1.97
N = 137

This indicated a need to separate egg masses according to position in further analysis.

A series of variance analyses and *F* tests were used to detect any differences between size of egg masses as it affects *O. kuwanai* parasitism percentage. At the 5% level of probability there was a significant* difference in each case as indicated below:

FIGURE 1.
FREQUENCY OF % PARASITISM OF GYPSY
MOTH EGG MASSES

1971



Above 1 foot --

NYT calculated *F* 2/60 = 24.18*
NYU calculated *F* 2/69 = 12.18*
NJT calculated *F* 2/72 = 8.75*
NJU calculated *F* 2/62 = 8.50*

Below 1 foot --

NYT calculated *F* 2/60 =336.46*
NYU calculated *F* 2/69 = 19.19*
NJT calculated *F* 2/72 =196.74*
NJU calculated *F* 2/51 =227.09*

Duncan's New Multiple Range Test, with corrections made for unequal replication as given by Steel and Torrie[14], was used to locate the source of the significant *F* values. The results of this test show a significant difference in percent parasitism according to size of gypsy moth egg masses. (Table 4).

TABLE 4.

RESULTS OF DUNCAN'S NEW MULTIPLE RANGE TESTS TO COMPARE MEAN PERCENT PARASITISM BY O. KUWANAI OF GYPSY MOTH EGG MASSES ACCORDING TO EGG MASS SIZE, LOCATION OF OVIPOSITION SITE, STATE, AND TREATMENT WITH CARBARYL. DATA FROM NEW YORK AND NEW JERSEY, 1971.

State and Treatment	Position	Egg Mass Size	$\bar{X}$	Comparison	L.S.R.	Significant?
NYT	A	Large	41.76	L-S	4.82	Yes
		Medium	35.80	L-M	4.58	Yes
		Small	30.90	M-S	3.79	Yes
NYU	A	Large	27.36	L-S	4.64	Yes
		Medium	32.55	L-M	4.41	Yes
		Small	38.21	M-S	4.26	Yes
NJT	A	Large	30.18	L-S	4.36	Yes
		Medium	36.15	L-M	4.15	Yes
		Small	38.63	M-S	4.15	No
NJU	A	Large	28.66	L-S	5.50	Yes
		Medium	34.23	L-M	5.26	Yes
		Small	39.31	M-S	4.43	Yes
NYT	B	Large	26.91	L-S	6.19	Yes
		Medium	33.27	L-M	5.88	Yes
		Small	41.24	M-S	4.86	Yes
NYU	B	Large	26.88	L-S	5.58	Yes
		Medium	30.60	L-M	5.30	No
		Small	38.34	M-S	5.13	Yes
NJT	B	Large	24.48	L-S	6.77	Yes
		Medium	31.49	L-M	6.43	Yes
		Small	38.26	M-S	6.43	Yes
NJU	B	Large	30.08	L-S	11.21	Yes
		Medium	35.90	L-M	10.64	No
		Small	42.25	M-S	5.59	Yes

Because there were differences in parasitism rates between positions above the forest floor as well as between egg mass sizes, it was necessary to analyze treatment means within each of these strata. The analysis of variance and the F test were used to detect any differences between the treatments: NYT, NYU, NJT, and NJU. Table 5 gives the results of the tests.

TABLE 5.

ANOVA: DIFFERENCES IN PERCENT PARASITISM BY O. KUWANAI OF GYPSY MOTH EGG MASSES TREATED VS. UNTREATED N.Y. & N.J. 1971

Position	Egg Mass Size	Total d.f.	Calculated F	Table F
Below 1' over forest floor	Small (51-250 eggs)	99	0.726	2.70
	Medium (251-500 eggs)	99	2.213	2.70
	Large (501-800 eggs)	63	0.684	2.76
Above 1' over forest floor	Small	99	0.949	2.70
	Medium	99	1.29	2.70
	Large	73	1.13	2.76

There was no significant differencesin percent parasitism between treated and untreated woodlands. This applies to collections taken from above or below a foot above the forest floor as well as to egg masses of various sizes.

Since there were no difference between treatment with carbaryl and no treatment, no further analyses were needed. Mean percent of parasitism could then be transformed from arcsin $\sqrt{\%}$ to the original scale as shown below:

	Small Egg Masses	Medium Egg Masses	Large Egg Masses
NYT	38.70% parasitism	34.89% parasitism	33.83% parasitism
NYU	38.88	34.95	31.38
NJT	39.16	34.95	32.04
NJU	39.16	36.39	31.78

DISCUSSION

Of the 2,122 gypsy moth egg masses examined, all parasitism was caused by Ooencyrtus kuwanai. The other major egg parasite, Anastatus disparis Ruschka, was conspicuous by its absence in both sprayed and unsprayed areas. Of the 50 or so O. kuwanai still present in gypsy moth eggs at this time, all were dead and in the adult stage - apparent victims of cold weather.

It is doubtful that carbaryl in water would have an impact on the population intensity of O. kuwanai when it is applied for gypsy moth control since at this time (June), O. kuwanai is within the gypsy moth eggs. Unless carbaryl had some means of penetrating the egg chorion, the chemical would not come in contact with Ooencyrtus. When O. kuwanai is again in the adult stage, carbaryl in water has degraded to less than toxic levels or is no longer present in the environment.

O. kuwanai evidently has excellent searching ability since all but two of 920 gypsy moth egg masses had some degree of parasitism by this insect.

Field men reported difficulty in finding egg masses in sprayed areas, especially those masses less than one foot above the forest floor. Those egg masses that they did find were usually large and hidden in rock crevices or the loose bark of fallen trees - both areas being dark and likely unattractive to a positively photo-responsive Hymenopteran such as O. kuwanai, at least during the searching portion of its life cycle.

One may only speculate about the probability of O. kuwanai completely eliminating a gypsy moth population under natural conditions, especially when starvation or other stress of gypsy moth caterpillars results in small egg masses. In our collection, only 10 of the 920 egg masses were completely destroyed by O. kuwanai. In each case, there were fewer than 210 eggs per mass, and other mortality factors were present. Three of the egg masses were from unsprayed woodlands and seven were from sprayed areas - much too small a sample for a meaningful comparison.

The calculations performed in this analysis will be repeated on data gathered in 1972 from the same 1971 treated and untreated woodlands to determine any impact on Ooencyrtus kuwanai populations two years after spraying with carbaryl.

Data used in the calculations will be on file at the Portsmouth Field Office for three years.

CONCLUSIONS:

Under the conditions encountered in the collection and analysis of the data, the following conclusions are drawn:

1. There was no impact on the population intensity of Ooencyrtus kuwanai when areas in New York and New Jersey were sprayed with one pound active ingredient carbaryl in 1971 for the suppression of gypsy moth populations. The percent parasitism of gypsy moth egg masses by O. kuwanai did not differ between sprayed and unsprayed woodlands.

2. The size of the gypsy moth egg mass has an inverse relationship to the percent of parasitism by O. kuwanai.

3. Large egg masses (over 500 eggs per mass) found in niches less than one foot above the forest floor had significantly less parasitism than those above that level.

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APPENDIX I.

Subsample representation by political units, timber type, and gypsy moth population levels for use in determining percentage of parasitism of gypsy moth egg masses by O. kuwanai, 1971.

NEW JERSEY TREATED WITH CARBARYL

Counties:	Towns:
Bergen	Byram
Morris	Frankford
Orange	Greenville
Passaic	Hardwick
Sussex	Hardyston
Warren	Jefferson
	Mahwah
	Newfoundland
	Pahaquarry
	Stillwater
	Westford
	West Milford
	Wanaque

NEW JERSEY NOT TREATED

Counties:	Towns:
Bergen	Bernards
Morris	Blairstown
Passaic	Cedar Knolls
Somerset	Chatham
Warren	Harding
	Hardwick
	Jefferson
	Lindy Lake
	Mahwah
	Norvin Green
	Watchung

NEW YORK, TREATED WITH CARBARYL

Counties:	Towns:
Orange	Bethel
Sullivan	Deerpark
Ulster	Forestburg
	Greenville
	Highland
	Mamakatine
	Mt. Hope
	Thompson
	Tusten
	Wawarsing

NEW YORK NOT TREATED

Counties:	Towns:
Orange	Deer Park
Sullivan	Forestburg
Ulster	Greenville
	Mt. Hope
	Tusten
	Wallkill
	Wawayanda

TIMBER TYPES

Oak	Mixed Hardwoods
Birch	Aspen
Maple	Northern Hardwoods
	Hickory

Gypsy moth population ranged from 0 to over 300 egg masses on 0.1 acre plot:

Egg Masses/0.1 acre -	0	1-25	26-50	51-75	76-100	101+
Frequency -	29	113	41	29	14	47

APPENDIX II.

Bartlett's test for homogeneity of variance of gypsy moth egg mass rate of parasitism between New York and New Jersey, and between no treatment and treatment with carbaryl, 1971

DATA TRANSFORMED TO ARCSIN $\sqrt{\%}$

Group	S^2	n-1	SS	$\frac{1}{n-1}$	log S^2	(n-1)(log S^2)
NYT	85.17	229	19503.655	.00437	1.93029	442.036
NYU	97.23	229	22264.708	.00437	1.98778	445.203
NJT	113.71	229	26039.681	.00437	2.05580	470.778
NJU	90.86	229	20807.489	.00437	1.95838	448.469
	Sums	916	88615.533	.01748	--	1816.486

$$\bar{S}^2 = \frac{88615.533}{916} = 96.7419 \therefore \log \bar{S}^2 = 1.98562$$

$$X^2_{3\ d.f.} = 2.3026\ (1.98562(916)-1816.486) = 5.389 \text{ not significant}$$

Table $X^2_{.05} = 7.81$

ORIGINAL DATA

Group	S^2	n-1	SS	$\frac{1}{n-1}$	log S^2	(n-1)(log S^2)
NYT	194.59	229	44561.11	.00437	2.28912	524.209
NYU	219.76	229	50323.94	.00437	2.34194	536.304
NJT	241.01	229	55190.17	.00437	2.38203	545.484
NJU	221.60	229	50745.96	.00437	2.34557	537.135
	Sums	916	200821.18	.01748	9.35866	2143.132

$$\bar{S}^2 = \frac{200821.18}{916} = 219.237 \therefore \log \bar{S}^2 = 2.34091$$

$$X^2_{3\ d.f.} = 2.3026\ (2.34091(916)-2143.132) = 2.64 \text{ not significant}$$

Table $X^2_{.05} = 7.81$